

## SLOT LOADED PROXIMITY COUPLED EQUILATERAL TRIANGULAR MICROSTRIP ANTENNA FOR QUAD BAND OPERATION AND ENHANCEMENT OF BANDWIDTH

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### ABSTRACT

In this paper, the bandwidth of proximity coupled equilateral triangular microstrip antenna is enhanced by loading slot on radiating patch of antenna. It can be seen that, the bandwidth of microstrip antenna is increased to a great extent when antenna is loaded with a square slot. In some applications where the increased bandwidth is needed, the designed microstrip antenna is one of the alternative solution. The proposed antenna achieved quad band frequency points between 2.75GHz - 9.14GHz. The bandwidth has been enhanced to a maximum value of 21.33% (1925MHz) in comparison to that of conventional microstrip antenna which resonates at 3 GHz with bandwidth of 6.97% (210MHz). This antenna may find applications in IMT (International Mobile Communication), IEEE802.16d WIMAX and in radar systems. The design considerations and experimentally measured results are presented and discussed.

**KEYWORDS:** Slot Loaded, Proximity Coupled, Equilateral Triangular, Bandwidth, VSWR, HPBW and Gain

### INTRODUCTION

In the present-time communication, antennas cover a wide range of applications in different areas, such as mobile communication, satellite navigation, internet services, automobiles and radars. Especially they are applied to microstrip antennas, because of their characteristics like low profile, light weight and low power handling capacity. However, gain and bandwidth are sometimes low and not sufficient in most of the applications [1,2]. Selection of the dynamic in terms of resonant frequency, polarization, pattern and impedance, the particular patch shape and mode was selected. Microstrip antennas have several advantages, they also have several disadvantages such as low gain, narrow bandwidth with low efficiency. To overcome from these disadvantages may be get solution by building many patch antennas. Modification of shape and using special materials could be useful to solve such backlashes of this type of antennas.

Normally, microstrip antenna constitutes a planer radiating architecture of desired shape of geometrical one of the side of dielectric substrate and a groundplane of other. Basically, it used microstrip radiating geometries were rectangular and circular [3,4]. Somehow, another shapes also concerned upon the application.

Coupling power to a microstrip antenna is as important as the selection of a suitable geometry for a particular application. A variety of feeding mechanisms are available and important among them are microstrip feed, co-axial feed, aperture coupled feed and proximity coupled feed [5-8]. The proximity coupled feed technique is used for the proposed microstrip antenna. It uses a two –layer substrate with the microstrip line on the lower layer and the patch antenna on the upper layer. The feedline terminates in an open end underneath the patch. This paper gives the information to choose the design specification of antennas to achieve the desired perspectives as well as the characteristics for the effective radiation

efficiency. Therefore, the difficulties in microstrip antenna design is to increase the bandwidth and gain [9, 10].

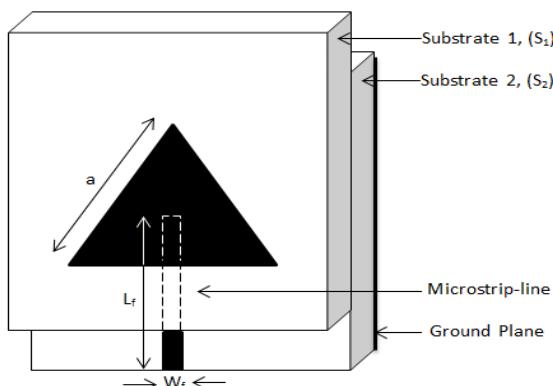
## ANTENNA DESIGN CONSIDERATION

To increase the bandwidth of microstrip antenna there were so many different methods are adopted like increasing in the substrate thickness, making use of a low dielectric constant substrate, using different feeding techniques and impedance matching and usage of slot antenna geometry. This work, propose a antenna is designed for the frequency of 3GHz utilizing the relations currently present in the literature of the design of equilateral triangular microstrip antenna using economy cost glass epoxy substrate having dielectric constant  $\epsilon_r = 4.2$ .

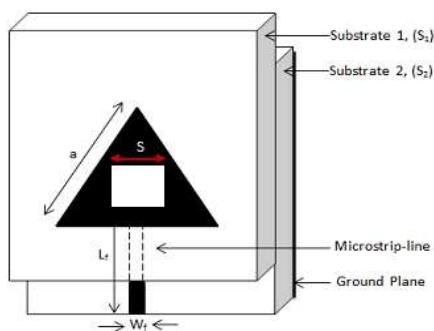
The shape of the proximity coupled equilateral triangular microstrip antenna(PCETMSA) is shown in Figure 1. The making of equilateral triangular microstrip patch antenna is side of length ‘a’ cm over a substrate  $S_1$  with substrate thickness ‘h’ cm. The value of ‘a’ is calculated by the equation (1),

$$a = \frac{2C}{3f_r \sqrt{\epsilon_r}} \quad (1)$$

whereas, the velocity of light which is mentioned in terms of C and  $f_r$  is the resonating frequency of the antenna. The feeding of microstripline of length  $L_f$  and width  $W_f$  is etched on the top surface of substrate  $S_2$ . Placing the substrate  $S_2$  below of the substrate  $S_1$  so that the tip of the feedline and the center of the radiating patch collide one over the other. The surface of the bottom of substrate  $S_2$  acts as the ground plane. Then it is same as in h and  $\epsilon_r$  of substrates  $S_1$  and  $S_2$ . The proposed antenna work is constructed using the computer software AUTOCAD to gain the best accuracy. The antenna is fabricated using the photolithography process.



**Figure 1: Geometry of PCETMSA**



**Figure 2: Top View of SSPCETMSA**

Further, the study is made by inserting a square slot on the radiating patch which provides high extent enhancement in bandwidth. The top view of a square slot loaded proximity coupled equilateral triangular microstrip antenna (SSPCETMSA) is shown in Figure 2. All the parameters of proposed antenna are given in Table 1.

**Table 1: Designed Specifications of the Proposed Antennas**

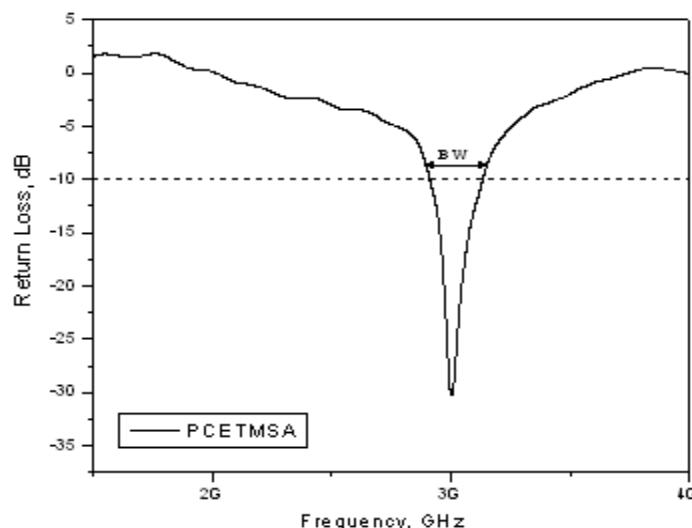
| Antenna Specifications                               | Dimensions in cm |
|--|------------------|
| Side length of equilateral triangle (a)              | 2.70             |
| Length of the slot S                                 | 10               |
| Length of the feedline $L_f$                         | 2.5              |
| Width of the feedline $W_f$                          | 0.633            |
| Length and width of the ground plane (Lg and Wg)     | 4.6              |
| Thickness of substrate $S_1$ and $S_2$ ( $h_1+h_2$ ) | 0.64             |

## EXPERIMENTAL RESULTS

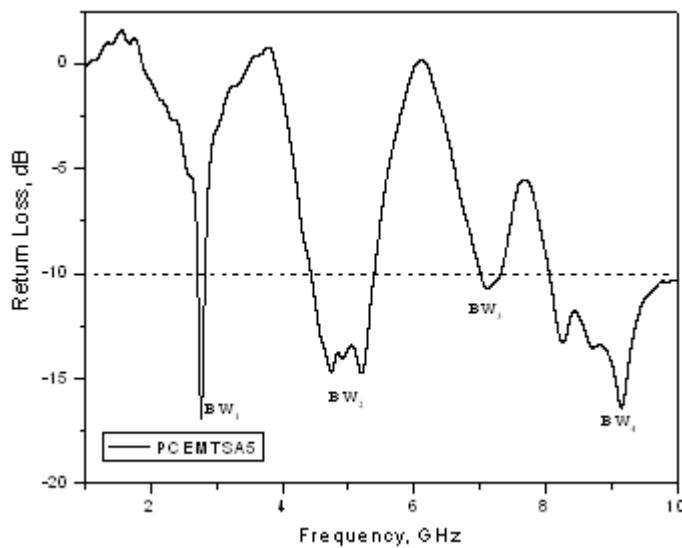
The impedance bandwidths over return loss less than -10 dB for the proposed antennas are measured. The measurements are taken on Vector Network Analyzer (Rohde & Schwarz, German make ZVK Model No. 1127.8651). The variations of return loss versus frequency of PCETMSA and SSPCETMSA antennas are shown in Figure 3 and Figure 4. The experimental impedance bandwidth is calculated using the equation (2),

$$BW = \left[ \frac{f_2 - f_1}{f_c} \right] \times 100\% \quad (2)$$

where,  $f_2$  and  $f_1$  are the upper and lower cut off points of resonating frequency when its return loss reaches -10 dB and  $f_c$  is a center frequency between  $f_1$  and  $f_2$ . The PCETMSA resonates at 3GHz with impedance bandwidth of 6.97% (2.91GHz - 3.12GHz). From the Figure 4, it is found that the SSPCETMSA resonates at quad bands of frequencies i.e,  $f_1$ ,  $f_2$ ,  $f_3$  and  $f_4$  with their corresponding impedance bandwidths  $BW_1 = 4.7\%$  (2.69GHz - 2.82GHz),  $BW_2 = 19.48\%$  (4.42GHz - 5.37GHz),  $BW_3 = 4.45\%$  (7GHz - 7.31GHz) and  $BW_4 = 21.33\%$  (8.06GHz-9.98GHz). The minimum return loss and VSWR measured are tabulated in Table 2.



**Figure 3: Variation of Return Loss v/s Frequency of PCETMSA**

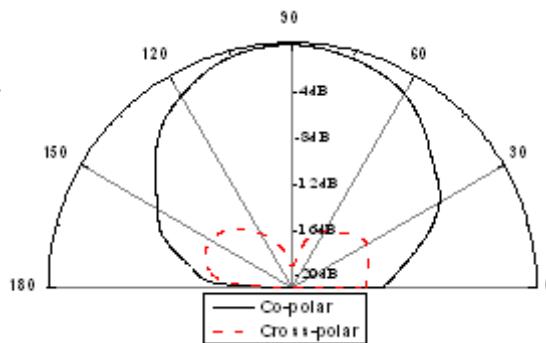


**Figure 4: Variation of Return Loss v/s Frequency of SSPCETMSA**

**Table 2: Measured Min. Return Loss and VSWR**

| Antennas | Freq. in GHz. | Min. Return Loss in dB. | VSWR |
|----------|---------------|-------------------------|------|
| PCETMSA  | 3.00          | -30.26                  | 1.12 |
| SSPCEMSA | 2.75          | -16.86                  | 1.81 |
|          | 4.92          | -13.96                  | 1.82 |
|          | 7.15          | -10.65                  | 1.78 |
|          | 9.14          | -16.37                  | 1.32 |

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and SSPCETMSA are measured at their resonating frequencies and are shown in Figure 5 to Figure 9. These figures indicate that the antennas show broad side radiation characteristics. Further, the calculated HPBW is given in Table 3.



**Figure 5: Radiation Pattern at 3 GHz**

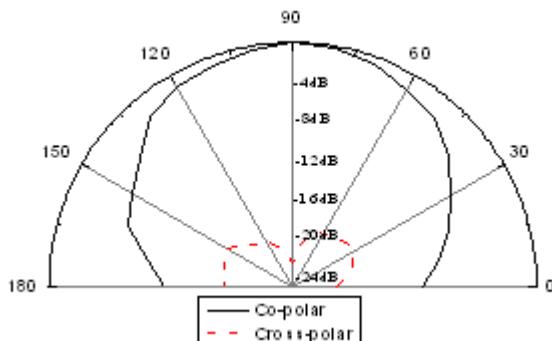


Figure 6: Radiation Pattern at 2.75GHz

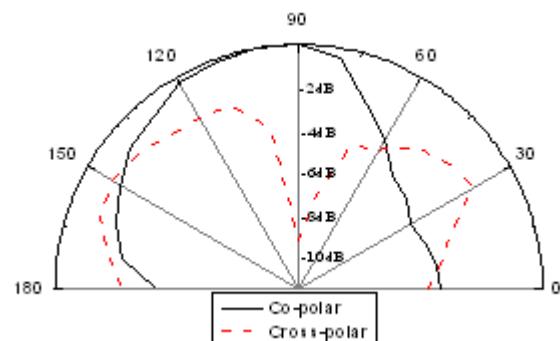


Figure 7: Radiation Pattern at 4.92GHz

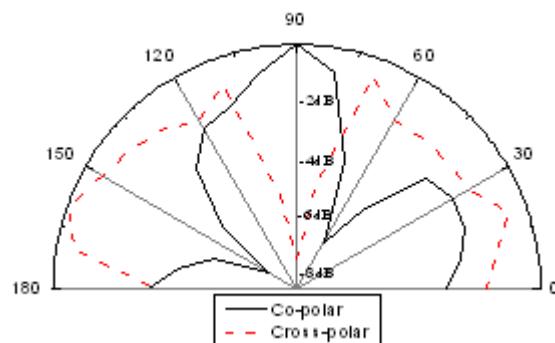


Figure 8: Radiation Pattern at 7.15GHz

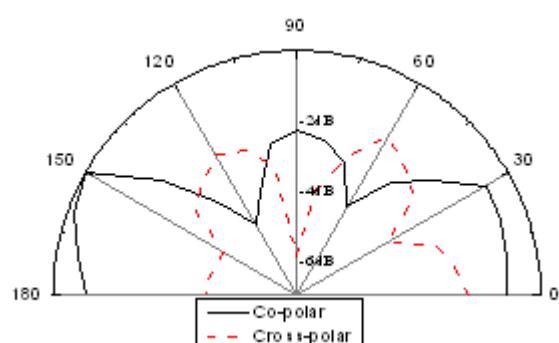


Figure 9: Radiation Pattern at 9.14GHz

The gain of proposed antenna is calculated using absolute gain method given by the equation (3),

$$G(dB) = 10 \log \left( \frac{P_r}{P_t} \right) - (G_t) dB - 20 \log \left( \frac{\lambda_0}{4\pi R} \right) dB \quad (3)$$

where,  $P_t$  and  $P_r$  are transmitted and received powers respectively,  $G_t$  is the gain of the pyramidal horn antenna and  $R$  is the distance between transmitting antenna and antenna under test. The gain of the antenna is also tabulated in Table 3.

Table 3: Calculated HPBW and Gain

| Antennas  | Freq. in GHz. | HPBW in degrees | Gain in dB |
|-----------|---------------|-----------------|------------|
| PCETMSA   | 3             | 72°             | 6.38       |
| SSPCETMSA | 2.75          | 85°             | 6.82       |
|           | 4.92          | 90°             | 0.26       |
|           | 7.15          | 30°             | 1.53       |
|           | 9.14          | 55°             | 1.18       |

## CONCLUSIONS

From the detailed study it is concluded that, the novel geometries of square slot loaded proximity coupled equilateral triangular microstrip antenna derived from PCETMSA are effective for producing quad band frequency. The radiation patterns of all the antennas are found to be broadsided and linearly polarized. The designed antennas are simple in their design, compact and they use low cost substrate material. These antennas may find applications in IMT, IEEE 802.16d WIMAX and in radar systems.

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